



Transportation Synthesis Report

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Deep-Strength and Full-Depth Asphalt Pavements

Prepared for
**Bureau of Highway Construction
And WHRP Flexible Pavements Technical Advisory Committee**

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Transportation Synthesis Reports (TSRs) are brief summaries of currently available information on topics of interest to WisDOT technical staff in highway development, construction and operations. Online and print sources include NCHRP and other TRB programs, AASHTO, the research and practices of other state DOTs, and related academic and industry research. Internet hyperlinks in TSRs are active at the time of publication, but changes on the host server can make them obsolete.

REQUEST FOR REPORT

The RD&T Program was asked to investigate the use of deep-strength and full-depth asphalt pavements by other state transportation agencies. We are also preparing a separate literature search listing academic publications on the topic. Of specific interest is how deep-strength and full-depth are defined, what role for rehabilitation and maintenance is assumed in the designs, information on successes, failures, and service lives if available, as well as knowledgeable contacts at each state.

SUMMARY

Most states use the term deep-strength interchangeably with perpetual pavement. Full-depth asphalt, another design that like deep-strength has been in use for 50 years, may also be referred to by states, and the definitions may be interchangeable. Perpetual pavement, it seems, may refer to either deep-strength or full-depth, though deep-strength seems more common.

The main distinction between these is base type. Full depth lies directly on subgrade, its base consisting of an asphalt layer. Deep-strength lies on an unbound, granular base course. Perpetual pavement refers specifically to a three-layer, mechanistic asphalt concept based in elastic theory. It uses a flexible bottom layer to contain bottom-up fatigue cracking, a middle layer for carrying load, and a stiff surface friction course that can be periodically milled and filled. With occasional surface work, the main structure is believed to good for 50 years or more.

National and state asphalt industry groups, some of which favor full-depth, others deep-strength, use these terms more than do state transportation agencies, and most such asphalt groups express a bias toward one style or another. A prominent Minnesota asphalt organization, for example, favors full-depth designs over deep-strength, while MnDOT engineers favor deep-strength.

According to *Better Roads*, perpetual pavement projects have been launched in the last two years in California, Wisconsin, Michigan, Texas, Oregon, Pennsylvania, Maryland, and Kentucky. We have not been able to confirm this claim, or determine whether a full-depth or deep-strength style carries the perpetual label. We have included here the industry-based conventional definitions for these three categories of thick HMA pavements, and look at several states that use deep-strength or perpetual designs in climates like Wisconsin's.

Pavement life information included is merely anecdotal. As we found in a September 2004 report – see <http://www.dot.wisconsin.gov/library/research/docs/tsrs/tsrpavementservicelife.pdf> – actual service life data for pavements has not been rigorously kept by state transportation agencies. This remains a goal of pavement management programs; some effort has been made to mine historical data for service life data, but only into broad categories of flexible and rigid.

INDUSTRY DEFINITIONS

Understandings of these pavement types are fairly uniform on asphalt industry Web sites. When a distinction between full-depth and deep-strength designs is made, it typically follows the model of the two publications below.

Better Roads, 2004. In March, 2004, *Better Roads* followed up a piece it published in 2002 by featuring perpetual pavement, describing it as a three-layer structure designed from the bottom up to resist fatigue. The lowest layer resists and confines bottom-up fatigue, the middle layer supports loads, and the top sacrificial layer offers friction for driving. Perpetual pavement, a mechanistic design, should last 50 years with periodic (15-20 years) mill-and-fill overlays. <http://www.betterroads.com/articles/mar04a.htm> and <http://www.betterroads.com/articles/feb02c.htm>.

Asphalt Magazine, 2000. The Fall 2000 issue of *Asphalt Magazine* presented a concept paper describing perpetual pavement, as well as defining full-depth and deep-strength asphalt pavements. Posted on many industry sites, this is a seminal statement on these designs. http://www.asphaltinstitute.org/upload/Perpetual_Pavements.pdf.

- Full-depth asphalt pavement is laid directly on subgrade soils;
- Deep-strength asphalt pavement uses a relatively thin aggregate base;
- Perpetual pavement embraces either design to provide thinner and longer-lasting pavements than conventional designs, limiting fatigue cracking to the bottom flexible layers, and containing pavement distress in stiff surface layers that can be milled and replaced.

STATE DEFINITIONS AND PRACTICES

Minnesota may have the most robust information of the listed states.

Minnesota. The following documents can be found on the Minnesota Asphalt Pavement Association Web site, <http://www.asphaltisbest.com/>. Various industry sites and documents often refer to this site. MAPA favors full-depth over deep-strength designs. However, MnDOT engineers say they haven't used full-depth for 15 to 20 years. They do, however, use a granular-base, deep-lift asphalt, though the term "deep-strength" doesn't seem to be in currency. Neither do they refer to "perpetual pavement," say engineers.

Full-Depth. Minnesota Asphalt Pavement Association has recently been favoring full-depth designs, according to this July 2003 paper. MAPA argues that full-depth may be superior to deep-strength because bound bases are stronger than unbound, in part because they are "nearly watertight"; because HMA bases add tensile strength; and because they enjoy layer equivalencies that allow thinner layers than aggregate at like strength.

<http://www.asphaltisbest.com/PDFs/Total%20Asphalt%20vs%20Granular%20Base%20Jun%202003.pdf>.

Full Depth, Deep-Strength, and PCC. MAPA commissioned a 2003 ERES Consultants study of deep-strength and full-depth asphalt pavement, as well as doweled Portland cement concrete pavements. Each type experiences similar performance lives. First overlays for high-volume roadways fall at about 11 years, for other roads about 18 years; life expectancy with overlays may be 40-60 years. See the MAPA summary at

<http://www.asphaltisbest.com/PDFs/4%20Page%20Color%20Flyer.pdf>.

MAPA Asphalt Paving Design Guide. Produced in 2004 by a task force of consultants, academics, MAPA and MnDOT officials, this guide refers to "perpetual pavements" as simply any long-lasting pavement. However, full-depth pavement and deep-strength (referred to as "Stabilometer R-Value Design" and "granular base," as opposed to "HMA base," which consists of aggregate, modifiers, and binder) are discussed in detail.

<http://www.asphaltisbest.com/PDFs/DESIGNGU.PDF>.

MnDOT Bituminous Engineering Unit. This site does not break down asphalt types, but it offers links to specifications, contacts and more. <http://www.mrr.dot.state.mn.us/pavement/bituminous/bituminous.asp>.

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Illinois. IDOT has drawn attention for a recent installation of deep-strength asphalt that employs a rubblized concrete base course. The design employs Superpave binders and stone matrix asphalt in overlays, and though it is most often referred to as a perpetual pavement, *Asphalt Magazine* notes it is too thick to be considered a true perpetual pavement. The latter would have entailed 11 inches of asphalt, but a tentative IDOT agreed to 17.5 inches. See *Asphalt Magazine*, http://www.asphaltinstitute.org/upload/Illinois_I_70_Technology_Showcase.pdf, and *Roads and Bridges*, <http://www.roadsbridges.com/rb/index.cfm?fuseaction=showArticle&articleID=5427&learnMore=yes&CFID=80155&CFTOKEN=20155737>.

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Ohio. If MAPA champions full-depth designs in Minnesota, Flexible Pavement of Ohio seems to wave the flag for deep-strength pavement. Stories from the Ohio asphalt industry poorly distinguish between full-depth and deep-strength asphalts; a review of several publications suggests this may be due to oft-quoted comments from Fred Frecker, Executive Director of Flexible Pavements of Ohio, and editor of its new quarterly magazine, *Ohio Asphalt*. However, FPO descriptions suggest deep-strength designs, and ODOT seems to recognize a distinction between the two. As with other perpetual pavement designs, both styles require occasional mill-and-fill attention and are projected to last over 50 years.

ODOT. The department's annual transportation awards include a category dubbed New Full Depth Asphalt Concrete Pavement – p. 17 http://www.flexiblepavements.org/admin/assets/newsletters/newsletter_22.pdf. In addition, the Asphalt Pavement Alliance has posted a report claiming with little description that ODOT will install deep-strength asphalt on I-71, and full-depth asphalt on I-70. http://www.asphaltinstitute.org/upload/Ohio_Interstates.pdf.

American Society of Highway Engineers. The ASHE's newsletter *Scanner* includes a recent article by Frecker which notes that the many deep-strength asphalt pavements in Ohio offer data from perpetual pavement designs, which are "essentially an improvement" of deep-strength designs. However, the article opens with a reference to full-depth asphalt, and its description of perpetual pavement does not describe an aggregate base course. <http://www.highwayengineers.org/scanner12202h.html>.

Ohio Asphalt. The Summer 2004 issue reports early results of an instrumented perpetual pavement on I-77. Details suggest a deep-strength design (p. 7). http://www.flexiblepavements.org/admin/assets/newsletters/newsletter_2.pdf.

Ohio Asphalt. The Spring 2004 issue describes State Route 73, a deep-strength design built in 1936, that has required only surface attention (pp. 6-7). http://www.flexiblepavements.org/admin/assets/newsletters/newsletter_28.pdf.

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Colorado. According to *Colorado Construction*, deep-strength asphalt, in use for decades, well exceeded its 20-year life expectancy. See http://colorado.construction.com/features/archive/0408_CAPA.asp. The Colorado Asphalt Association defined perpetual pavement as a three-layer, deep-strength pavement with a life exceeding 50 years – <http://www.co-asphalt.com/FAQ/index.cfm>.

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Delaware. Called deep-strength, pavement described in a 1999 Asphalt Institute bulletin uses three-layer, 14-inch asphalt over 12 inches of base course. However, an engineer in the DelDOT materials and research office says that DelDOT uses no deep-strength. http://www.asphaltinstitute.org/upload/HMA_Saves_Dollars_In_Delaware.pdf.

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Washington. Often cited as a perpetual pavement builder, WSDOT has won awards for 30-year-old asphalt pavements on I-90. At WSDOT, engineers refer to thick pavements as full-depth pavements, which because of their crushed rock unbound base courses would generally be referred to elsewhere as deep-strength asphalt pavement.

Washington Asphalt Pavement Association. WAPA describes perpetual pavement as a three-layer system on a solid base with a CBR of over five percent. Several state asphalt associations post this description. http://www.asphaltwa.com/wapa_web/modules/06_structural_design/06_perpetual.htm.

WSDOT engineers say they use a granular base course. Thickness of layers varies with expected ESALs or with desired service life. Pavements expected to last 20, 40, or 50 years, are often referred to as full-depth.

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